REMARKS

Claims 7, 8, 23, 24, 33 and 34 have been amended. Claims 4, 14, 38-54 and 56 have been canceled. Claims 1-3, 5-13, 15-37 and 55 are currently pending.

Claims 1-3, 5, 6, 9, 11 and 12 stand rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Publication No. 2002/0171077 to Chu et al. (Chu). This rejection is respectfully traversed.

Independent claim 1 recites a pixel cell for an image sensor, comprising, among other elements:

> a photodiode for generating charge in response to light and for amplifying the generated charge, the photodiode being formed within a substrate and below an upper surface thereof and comprising at least two of a first layer having a first band gap and at least two of a second layer having a second band gap, wherein the first layers are alternated with the second layers, wherein the first layers are not in direct contact with one another and the second layers are not in direct contact with one another, and wherein the at least two first layers and the at least two second layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field . . . .

The Office Action states that Chu teaches forming a photodiode that includes Chu's layers 35 and 36. Office Action at 3. However, the Office Action mischaracterizes the elements of Chu. Chu's FIG. 4A embodiment includes a relaxed buffer layer 38 between the buffer layer 2 and layer 37. The buffer layer 38 includes alternating layers of $Si_{1-x}Ge_x$ 35 and $Si_{1-z}Ge_z$ 36, to create a symmetrically strained superlattice with respect to the layer 37, which is $Si_{1-y}Ge_y$, where $x<y<z$.

Layers 35 and 36 are not part of Chu's metal-oxide-metal photodetector. Instead, Chu's photodetector includes the electrodes 11 that sit on the surface of the absorbing layer 3 (or 37 in the case of the FIG. 4A embodiment). The electrodes 11 are configured "such that a bias applied between adjacent electrodes, as shown in FIG. 1E, creates an electric field that penetrates into the underlying absorbing layer 3. Light or radiant 14 energy incident from or passing through surface 8

creates free carriers, electrons 15 and holes 16, in layer 3 that travel to electrodes 11, creating a current signal that is proportional to the power of the incident light." Chu at [0036]. Further, Chu states that the layer 38 (made up of layers 35 and 36) should be configured "so that photogenerated carriers are not trapped in the potential wells formed by the strained layers 35 and 36." Chu at [0039]. According to Chu, this result is achieved by having a smooth potential profile as shown in FIG. 4B, rather than an abrupt one. Thus, contrary to the Office Action's contention, Chu's layers 35 and 36 are not part of Chu's MSM photodetector.

Accordingly, Chu does not teach or suggest "a photodiode for generating charge in response to light and for amplifying the generated charge, the photodiode being formed within a substrate and below an upper surface thereof and comprising at least two of a first layer having a first band gap and at least two of a second layer having a second band gap, wherein the first layers are alternated with the second layers, wherein the first layers are not in direct contact with one another and the second layers are not in direct contact with one another, and wherein the at least two first layers and the at least two second layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field," as recited by claim 1.

Nothing in Chu teaches or suggests these limitations of claim 1. In fact, according to Chu, it is the transistor 18 that creates an amplified signal, not the MSM photodetector. Chu at [0037].

For at least these reasons, withdraw of this rejection is respectfully requested.

Claims 7, 8, 10, 13 and 55 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Chu in view of U.S. Patent No. 5,818,322 to Tasumi (Tasumi). This rejection is respectfully traversed.

Claims 7, 8, 10 and 13 depend from claim 1.

Similarly to claim 1, independent claim 55 recites a pixel cell for an image sensor, comprising, among other elements:

> a photodiode for generating charge in response to light and for amplifying the generated charge, the photodiode being formed within a trench in a substrate and comprising at least two of a first layer having a first band gap and at least two of a second layer having a second band gap, wherein the first layers are alternated with the second layers, wherein the first material layers are not in direct contact with one another and the second material layers are not in direct contact with one another, and wherein the at least two first layers and the at least two second layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field . . . .

As discussed above, Chu fails to teach or suggest all of the elements of independent claim 1. For at least the same reasons, Chu does not teach or suggest all elements of claim 55.

Tasumi relates to a waveguide and is cited for teaching that layers of Si are doped to a first conductivity type and layers of SiGe are doped to a second conductivity type, a photodiode in a trench, and various thicknesses and compositions for particular layers. Tasumi, even when considered in combination with Chu, does not supplement the deficiencies of Chu.

In addition, with respect to claims 7 and 8 (as amended), Tasumi also fails to teach that the first and second conductivity types are different. For at least these reasons, withdraw of this rejection is respectfully requested.

Claims 15-22, 25, 27-32, 35-37 and 55 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Chu in view of Tasumi and U.S. Patent No. 6,232,626 to Rhodes (Rhodes). This rejection is respectfully traversed.

Claims 15-19 depend from claim 1.

Similarly to claim 1, independent claim 20 recites an image sensor, comprising, among other elements:

> an array of pixel cells at a surface of a substrate, wherein at least one of the pixel cells comprises a photodiode formed within the substrate and below an upper surface thereof, the photodiode comprising at least two of a first layer comprising a first material and at least two of a second layer comprising a second material, wherein the first layers are not in direct contact with one another and the second layers are not in direct contact with one another, wherein the layers are configured such that a difference between the conduction band energies of the first and second materials and a difference between the valence band energies of the first and second materials promotes ionization by a first carrier type and suppresses ionization by a second carrier type in the presence of an electric field and wherein the first layers are alternated with the second layers . . . .

Likewise, independent claim 32 recites an image sensor, comprising, among other elements:

> an array of pixel cells, wherein at least one of the pixel cells comprises: a photodiode formed below an upper surface of a substrate, the photodiode comprising at least two layers of Si alternating with at least two layers of Si_xGe_{1-x}, wherein the Si layers are not in direct contact with one another and the Si_xGe_{1-x} layers are not in direct contact with one another, and wherein the layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field . . . .

Further, independent claim 35 recites a processor system, comprising, among other elements:

> a processor; and an image sensor coupled to the processor, the image sensor comprising: an array of pixel cells, at least one of the pixel cells comprising: a photodiode formed below an upper surface of a substrate, the photodiode comprising at least two layers of Si alternating with at least two layers of Si_xGe_{1-x}, wherein the Si layers

> are not in direct contact with one another and the Si_xGe_{1-x} layers are not in direct contact with one another, and wherein the layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field .
> . . .

As discussed above, neither Chu nor Tasumi, even when considered in combination, teach or suggest all of the elements of independent claims 1 and 55. For at least the same reasons, Chu does not teach or suggest all elements of claim 32 and 35.

Rhodes is cited for teaching: a pixel configuration including a reset and transfer transistor, using photodiodes in a CCD image sensor, an SOI substrate, a pixel array configuration, readout circuitry, and an image sensor coupled to a processor. Rhodes, however, does not supplement the deficiencies of Chu and Tasumi. For at least these reasons, withdraw of this rejection is respectfully requested.

Claims 23, 24, 26, 33 and 34 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Chu in view of Tasumi and Rhodes. This rejection is respectfully traversed.

Claims 23, 24 and 26 depend from claim 20. Claims 33 and 34 depend from claim 32.

As discussed above, none of Chu, Tasumi and Rhodes, even when considered in combination, teach or suggest all of the elements of independent claims 20 and 32.

In addition, with respect to claims 23, 24, 33 and 34 (as amended), as acknowledged by the Examiner, Tasumi also fails to teach that the first and second conductivity types are different.

For at least these reasons, withdraw of this rejection is respectfully requested.

In view of the above, Applicant believes the pending application is in condition for allowance.

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Respectfully submitted,

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